Leveraging DegenGeom for Multi-Fidelity Analysis

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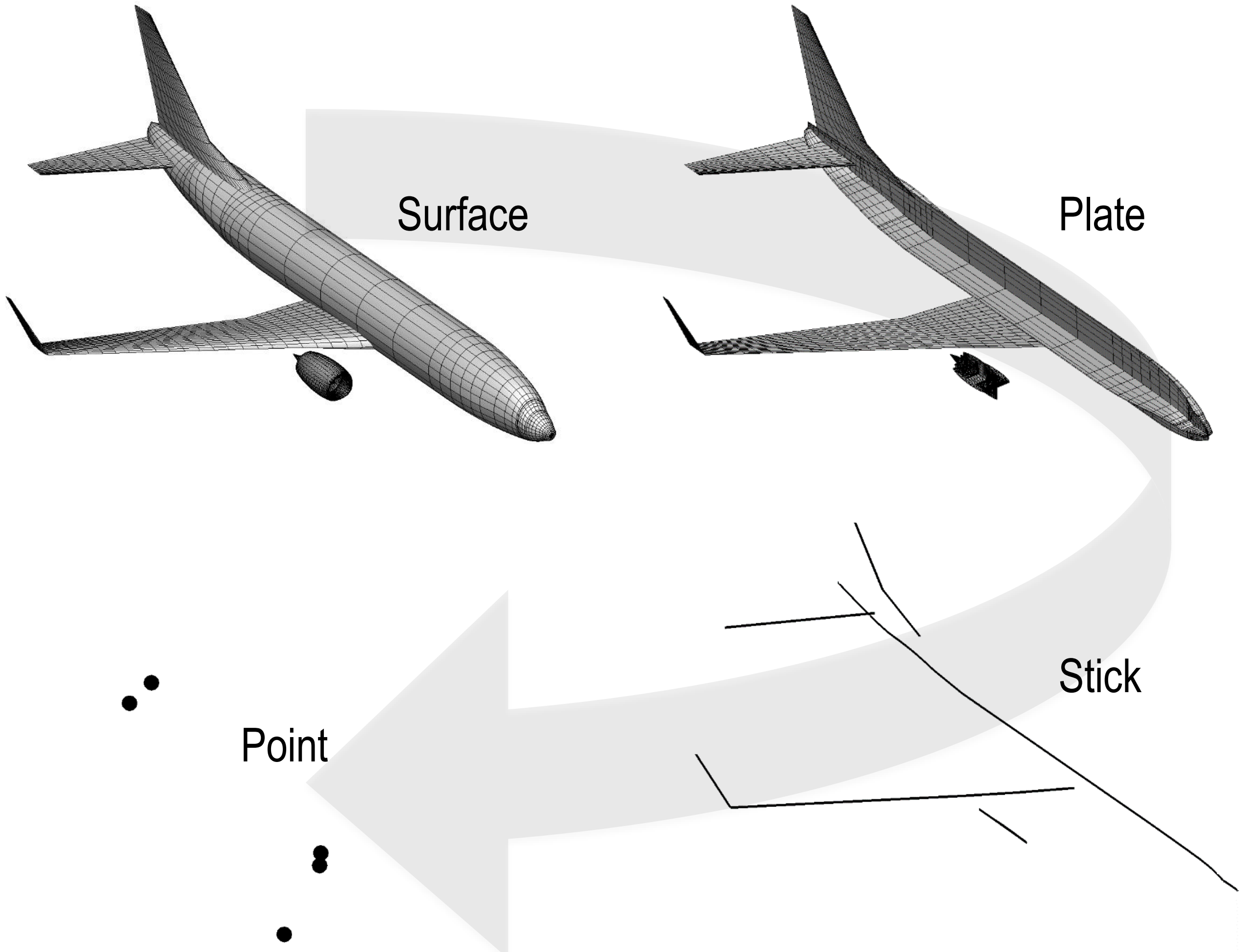
Outline

- Introduction
- Motivation and Goal
- Discrete Data Mapping
- Implementation
- Subsonic Transport Example
- Concluding Remarks

Introduction

- Early conceptual design studies traditionally performed using lower-order analysis methods on simplified geometrical representations.
- Transition to higher-order analysis using a more representative geometry as the design becomes more refined.
- This transition typically requires complete re-creation of the geometry.
- Discontinuities in geometrical representation are even more of a problem in newer multi-fidelity approaches.

OpenVSP Degenerate Geometry



Motivation

- Nodes of degenerate models are consistent with the geometric abstraction of the analysis method, therefore they could also serve as repositories for the resulting analysis data.
- These results can be made available to subsequent analyses in other disciplines, always maintaining the link to the master geometry.
- This internal data storage capability can greatly facilitate the creation of multi-disciplinary, multi-fidelity analysis, design and optimization processes.

Goal

- Extend the functionality of OpenVSP's degenerate geometric models to also store analysis results associated with the geometry.
- Implement a method to simultaneously map analysis results onto the nodes of all the other degenerate models.
- Make stored data available to subsequent higher- and lower-order analyses in whatever level of abstraction they require, regardless of the degenerate model on which the original analysis was based.

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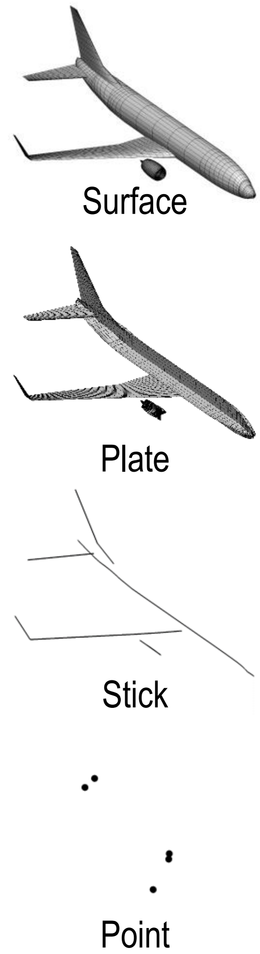
Discrete Data Mapping

Analysis results are mapped onto discrete nodes of degenerate models in three ways:

1. Results mapped onto nodes of the same order as the analysis.
2. Results mapped onto lower-order degenerate models (*aggregation*).
3. Results mapped onto higher-order degenerate models (*disaggregation*).

Aggregation and Disaggregation

Degenerate Type



Aggregation
- Integration
- Differencing
- Averaging

Disaggregation
- Shape function
- Scaling
- Interpolation
- RSEs

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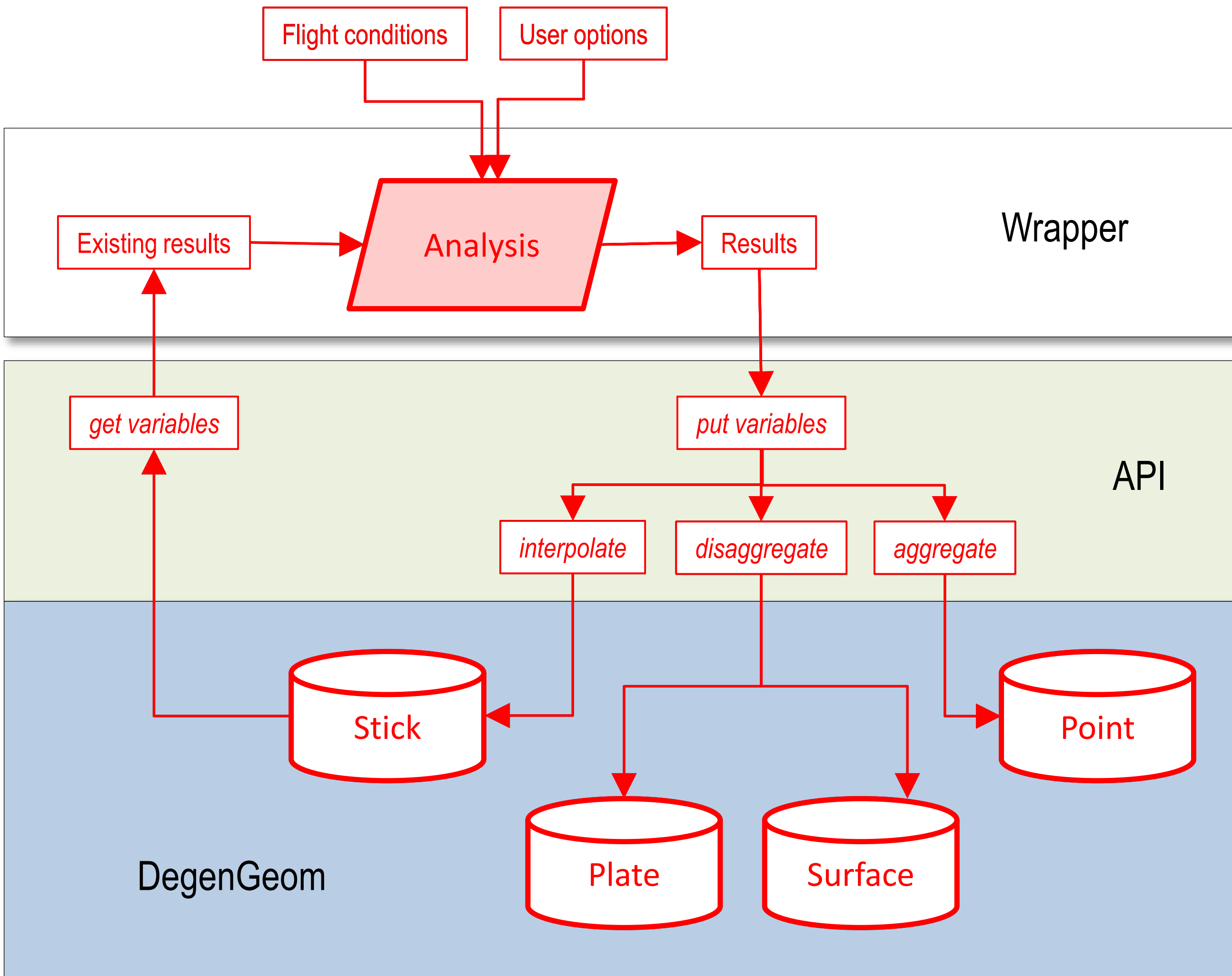
Implementation

- Mapping process implemented as a Java™ class name DegenGeom.
- DegenGeom object instantiated by parsing a Degenerate Geometry file exported by OpenVSP.
- Application program interface (API) makes data access and mapping methods available to wrappers for individual analysis methods.
- Aggregation and disaggregation operations performed automatically when analysis results are processed.
- DegenGeom objects are serializable and can be passed as output, carrying all analysis results for use by subsequent analysis methods.
- DegenGeom object is typically the only output needed.

Wrapper and API

Analysis method based on the degenerate Stick model



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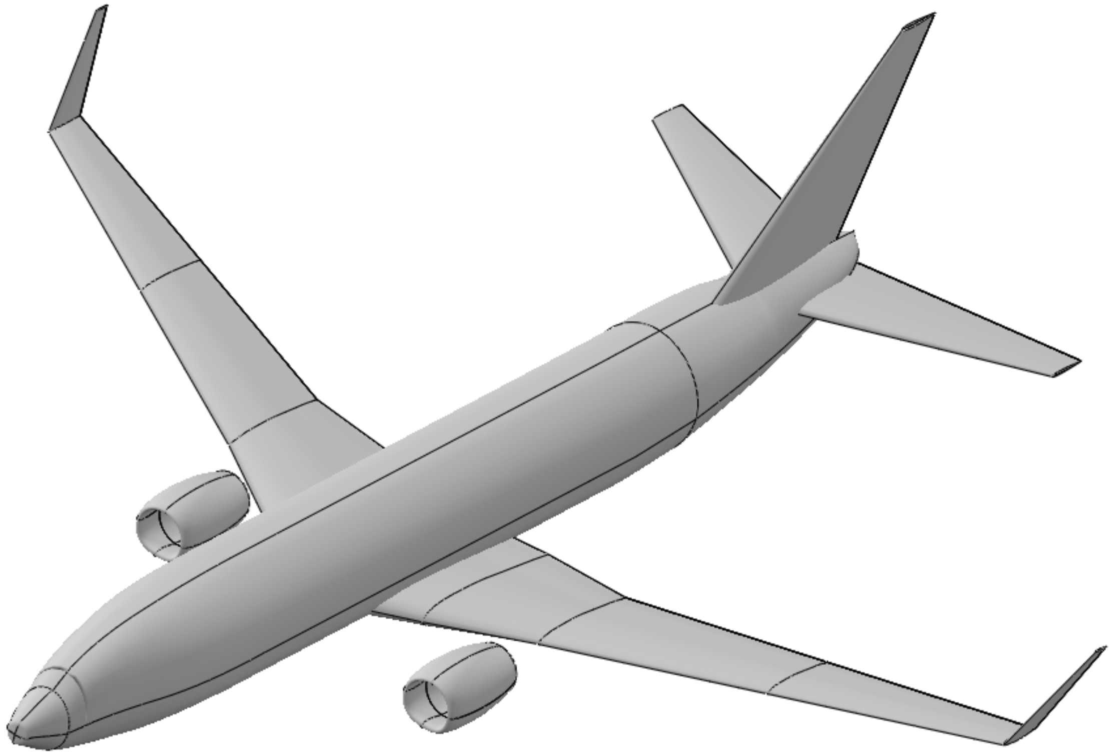
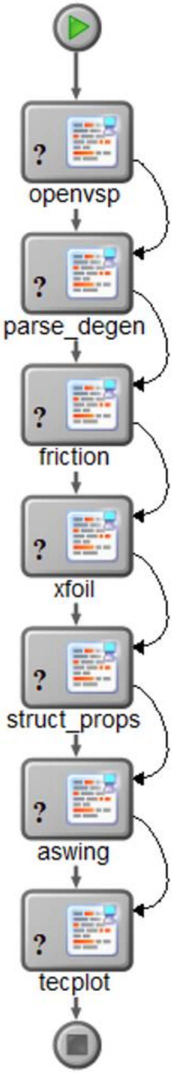
Single-Aisle Transport in OpenVSP



Analysis Process

- FRICTION: profile drag of fuselage
- XFOIL: sectional aerodynamic coefficients of lifting surfaces
- ASWING: aero-structural analysis of full configuration

ModelCenter® Process Model



OpenVSP

Parse degenerate models

FRICTION analysis

XFOIL analysis

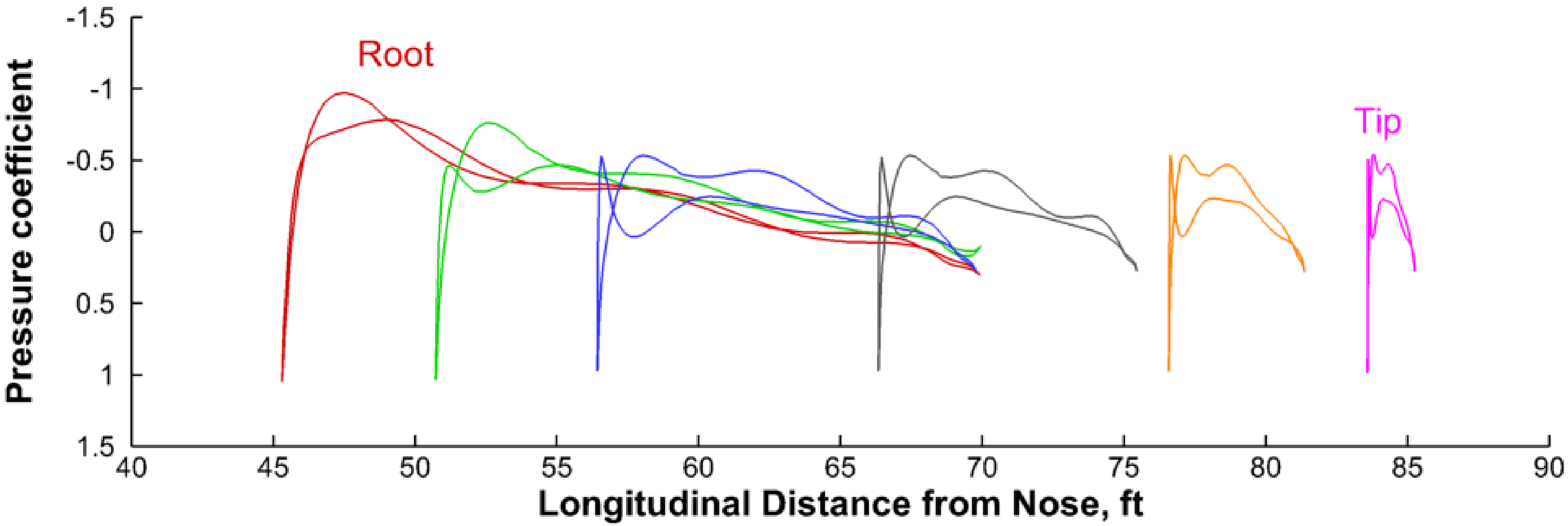
Define material properties

ASWING analysis

Tecplot

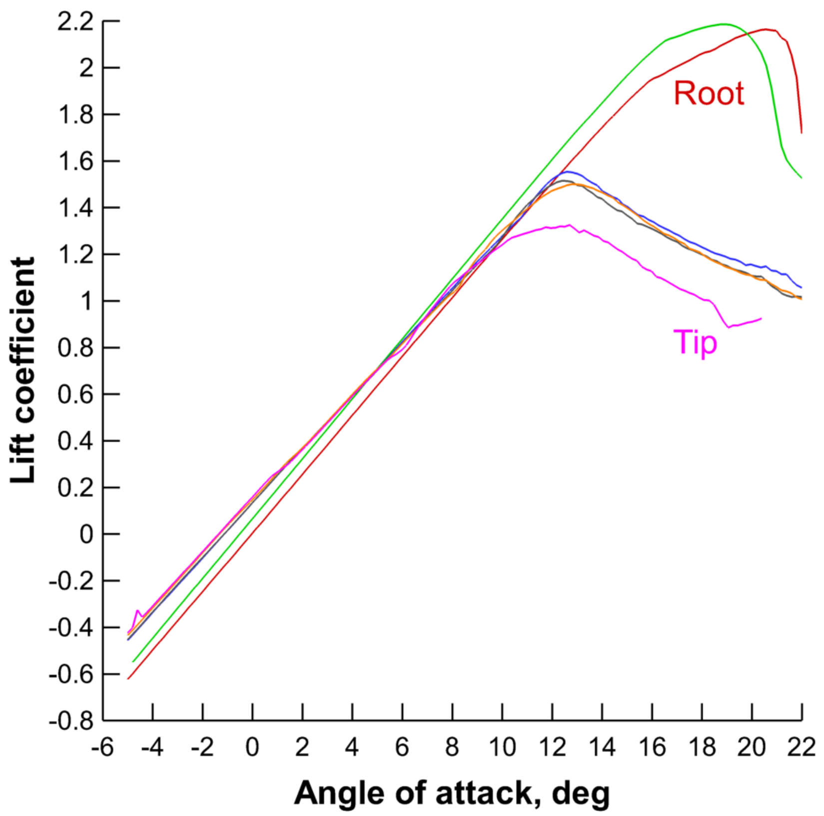
XFOIL Sectional Press. Distributions

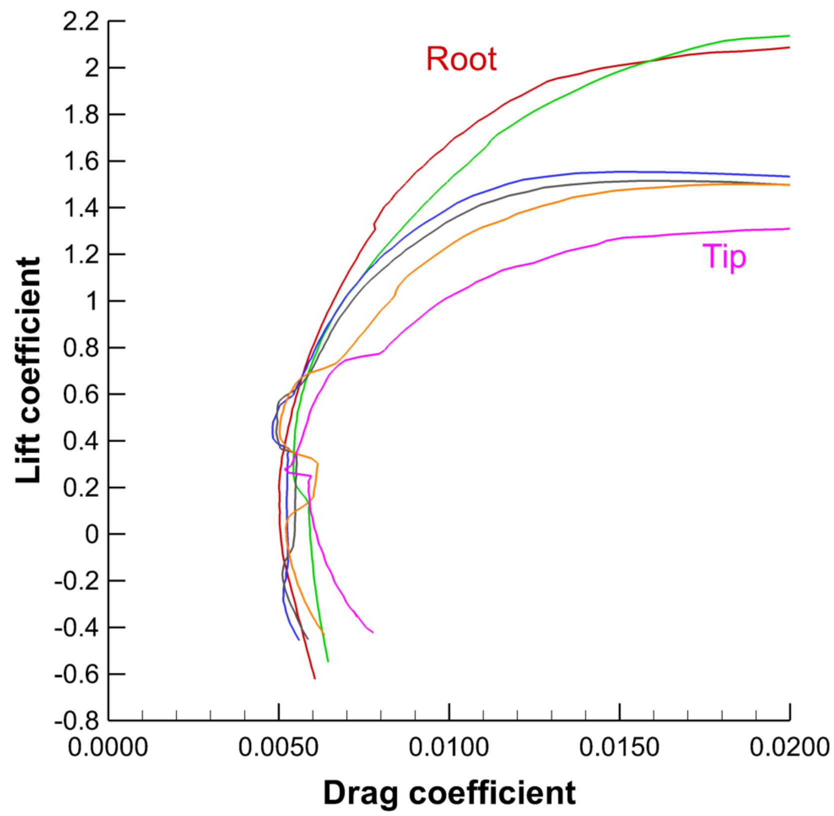
$$M_\infty = 0.3, h = 10{,}000 \text{ ft}, \alpha = 0$$



XFOIL Sectional Polars

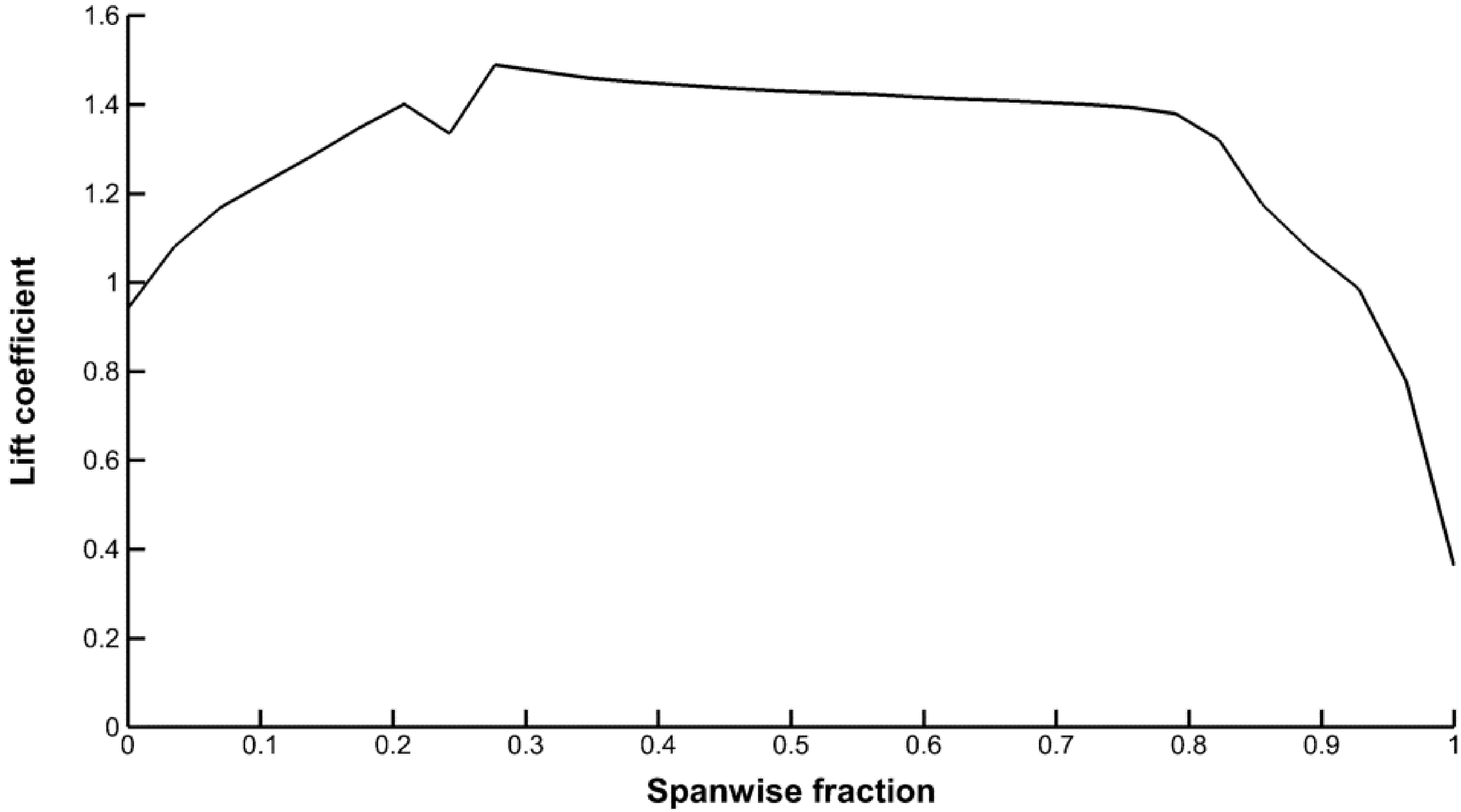
$$M_\infty = 0.3, h = 10{,}000 \text{ ft}$$





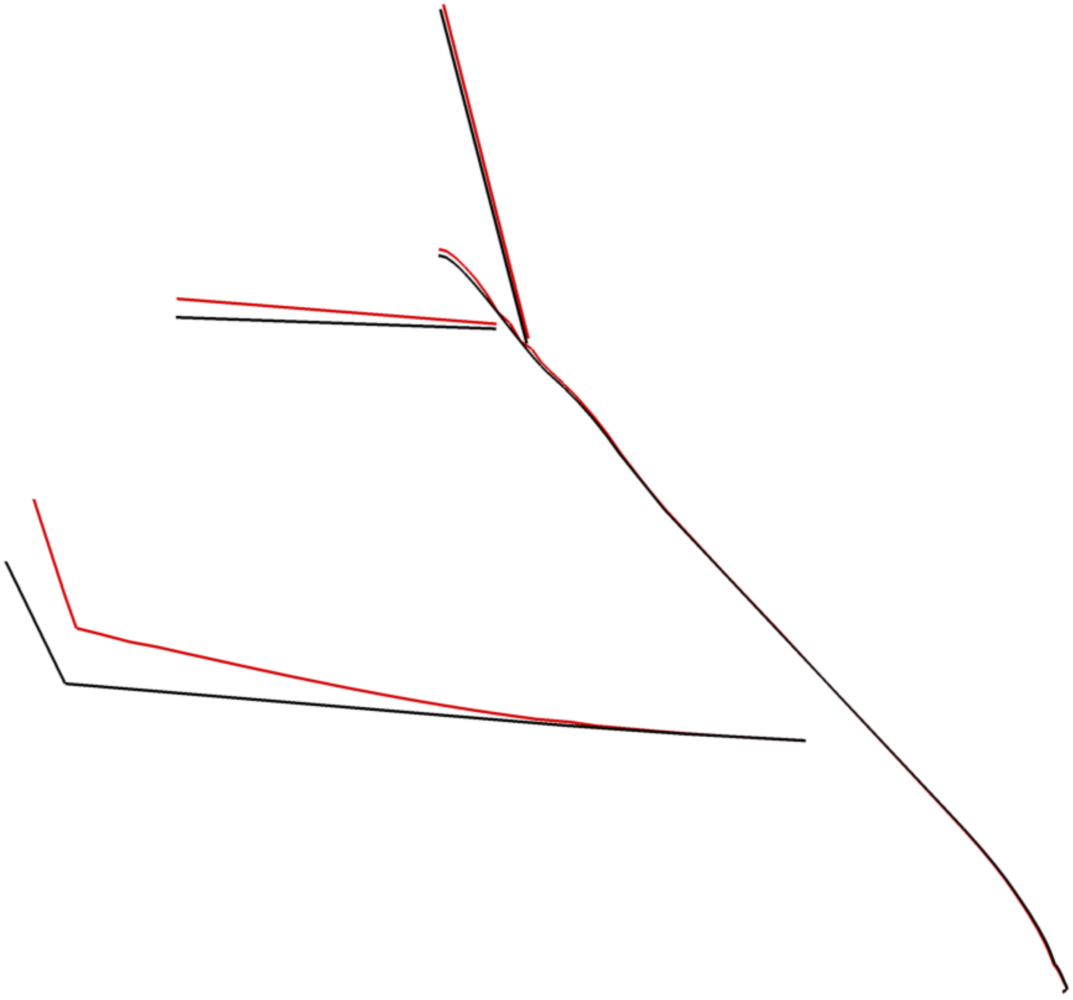
ASWing Spanwise Lift Distribution

Quasi-steady 2.5-g pull-up at $V_{\text{eas}} = 250$ kt, $h = 10{,}000$ ft



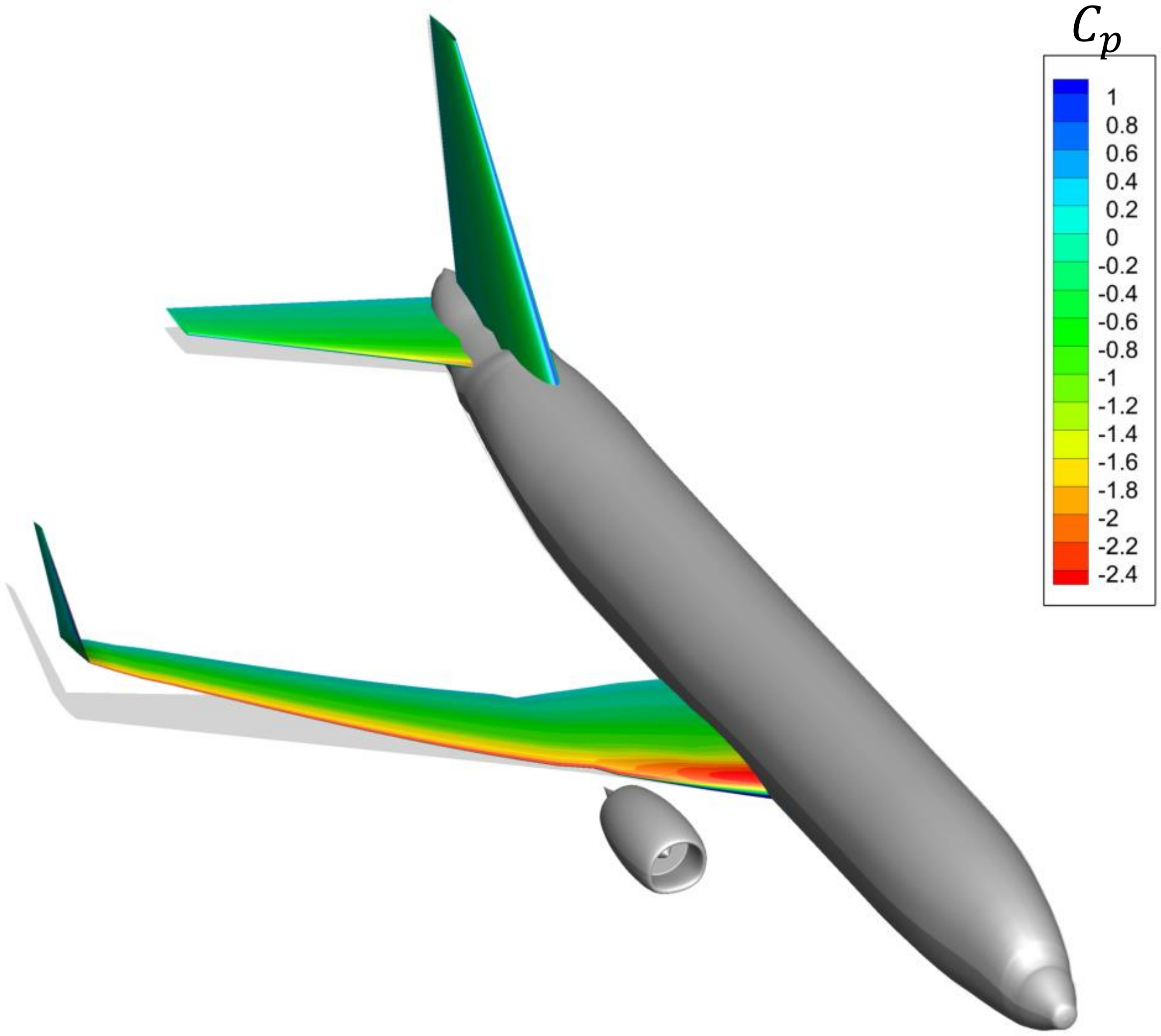
ASWing Deflections

Quasi-steady 2.5-g pull-up at $V_{\text{eas}} = 250 \text{ kt}$, $h = 10{,}000 \text{ ft}$



ASWing Results Mapped Onto Surface

Quasi-steady 2.5-g pull-up at $V_{\text{eas}} = 250$ kt, $h = 10{,}000$ ft



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Concluding Remarks

- Aggregation and disaggregation processes currently formulated in a mostly ad-hoc manner depending on the specific analysis method.
- It should be possible to further automate these processes, defining universal mapping algorithms that automatically enforce consistency and reversibility.
- Surface model components are maintained as separate, non-intersected surfaces. We could extend these capabilities by also applying them to the intersected, unstructured surface mesh exported by OpenVSP.

Acknowledgements

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